DETACHABLE SURGICAL DEVICES FOR TISSUE RETRACTION AND MANIPULATION

FIELD OF THE INVENTION

[0001] The present invention relates generally to surgical devices, and more particularly, to a surgical device for retracting tissue and manipulating a vessel.

BACKGROUND OF THE INVENTION

[0002] Endoscopic vessel harvesting (EVH), particularly of the greater saphenous vein in the leg and the radial artery in the arm, is a surgical procedure for obtaining a graft vessel for a coronary artery bypass graft (CABG) procedure. A physician's assistant (PA) typically performs the EVH on one or both legs and/or arms of the patient by operating endoscopically with instruments actuated at a position remote from the operating site to harvest saphenous veins and/or radial arteries.

[0003] Conventional techniques for harvesting these vessels involve an incision length approximately equal to the length of the vessel being harvested. More recently, various bipolar endoscopic vessel-harvesting devices have been developed for removing saphenous veins or radial arteries in a minimally invasive manner. See, e.g., U.S. Patent Nos. 6,464,702 (Schulze), 6,206,823 (Kolata), 5,902,315 (Dubois), and U.S. Patent Application Publication No. 2003/0065348 (Hess), each of which is hereby incorporated by reference. Known methods and devices for performing vessel dissection are discussed in detail in U.S. Patent Nos. 5,667,480 (Knight) and 5,722,934 (Knight), both of which are incorporated herein by reference.

[0004] One example of such a device is disclosed in U.S. Patent No. 5,928,138 ("Method and Devices for Endoscopic Vessel Harvesting", assigned to Ethicon Endo-Surgery, Inc., and issued on Jul. 27, 1999) discloses an optical retractor/dissector having a concave working head. A commercial version of this optical dissector is called the CLEARGLIDE® system and is available from Ethicon, Inc., Somerville, N.J. The CLEARGLIDE system provides good access and visibility to the surgical site along the greater saphenous vein. When using the CLEARGLIDE system, the PA typically also uses other endoscopic, surgical dissection instruments to isolate the vessel from surrounding tissues. The PA introduces these instruments beneath the shaft of the CLEARGLIDE retractor so as to position the end effector of the instrument within a working space created by the retractor to operate on tissues.

[0005] Current devices and methods for endoscopic vessel harvesting that utilize mechanical tissue retraction require great dexterity from medical staff for proper use. Normally, one hand manipulates the tissue retractor, while another hand manipulates one or more tools to perform side branch hemostasis, transection and verification of side branch transection. This set of tools provides the user with great flexibility when the procedure requires the user to access difficult-to-reach areas. The skills required to manipulate multiple tools simultaneously, however, take some time to refine, and difficult to master for novice users and those who do not have innate, hand-eye coordination.

[0006] This invention addresses the difficulty of learning an endoscopic vessel harvesting procedure by minimizing the hand-eye coordination load on new users. Specifically, the tissue retractor is designed to dock with a second tool (often referred to herein as the multitool) that provides tools for visualization, vessel manipulation, side branch coagulation, and transection. In this way, the tissue retractor and multitool can be manipulated by using one hand. The docking arrangement permits the multitool to be rotated or deflected away from the retractor with respect to the longitudinal axis of the retractor when the retractor and multitool are docked so as to provide the user with additional flexibility in the working space and to permit vessel manipulation. The multitool can also undock from the retractor to provide greater flexibility to accommodate more advanced users.

SUMMARY OF THE INVENTION

[0007] Therefore it is an object of the present invention to provide instruments and methods for their use that overcome the disadvantages of conventional instrumentation known in the art.

[0008] The system according to the present invention is a set of two instruments. A retractor is used primarily for gross tissue retraction, but also provides for fine tissue manipulation using thumb-activated controls. A multitool instrument provides a means for endoscopic visualization, side branch hemostasis, and transection. The tools can be used independently or together. A docking feature located on the multitool allows the retractor and the multitool instrument to be docked together, thereby making the two instruments act as one.

[0009] In a preferred embodiment, a system for harvesting a vessel in a patient includes a retractor for retracting tissue, that includes a port and a tool for manipulating tissue. The tool includes a docking feature for releasably connecting the tool to the port.

[00010] One embodiment of the invention provides a system that includes a retractor having a housing formed by a wall having an inner surface and an opening therein, and a retractor shaft that extends distally from the housing. The system also includes a tool having a handle, at least one tube extending from the handle, and a dock. The dock is disposed on the at least one tube and includes a latch configured to engage the housing when the at least one tube is disposed within the opening of the retractor.

BRIEF DESCRIPTION OF THE DRAWINGS

[00011] These and other features, aspects, and advantages of the apparatus and methods of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

[00012] FIG. 1 is a perspective view of the endoscopic system including a retractor and multitool device in an undocked configuration;

[00013] FIG. 1A is a rear view of the retractor of FIG. 1;

[00014] FIG. 2 is a perspective view of the endoscopic system including the retractor and multitool device in a docked configuration;

[00015] FIG. 3 is a perspective view of a preferred implementation of a retractor of the present invention;

[00016] FIG. 4 is a perspective view of the retractor of FIG. 3, the retractor having a first paddle in an extended position;

[00017] FIG. 5 is a perspective view of the retractor of FIG. 3, the retractor having a first and second paddle in an extended position;

[00018] FIG. 5A is sectional view of the retractor shown in FIG. 5 taken along line 5A-5A;

[00019] FIG. 6 is a sectional view of the retractor shown in FIG. 3 taken along line 6-6;

[00020] FIG. 7 is a sectional view of the retractor shown in FIG. 4 taken along line 7-7;

[00021] FIG. 8 is a sectional view of the retractor shown in FIG. 5 taken along line 8-8;

[00022] FIG. 9 is a side view of the retractor shown in FIG. 4;

[00023] FIG. 10 is a side sectional view of the retractor shown in FIG. 3;

[00024] FIG. 11 is an exploded view of the retractor shown in FIG. 3 with the handle omitted for clarity;

[00025] FIG. 12 is an exploded view of the retractor shown in FIG. 3;

[00026] FIG. 13 is an exploded view of the multitool device shown in FIG. 1;

[00027] FIG. 14 is a perspective view of one embodiment of the dock and dock port of the invention in a docked configuration;

[00028] FIG. 15 is a side view of the retractor and multitool device shown in FIG. 2 in a docked configuration;

[00029] FIGS. 16A and 16B are side and end sectional views of a first alternative docking arrangement that permits radial movement of the multitool device with respect to the retractor;

[00030] FIGS. 17A and 17B are side and end sectional views of a second docking arrangement that permits axial movement of the multitool device with respect to the retractor; and

[00031] FIGS. 18A and 18B are perspective views of a third alternative embodiment of the dock and dock port of the invention in an undocked configuration and a docked configuration, respectively.

DETAILED DESCRIPTION OF THE INVENTION

[00032] Although this invention is applicable to treat numerous and various types of tissue, it has been found particularly useful in the environment of harvesting blood vessels. Therefore, without limiting the applicability of the invention to harvesting vessels such as the saphenous vein or radial artery, the invention will be described in such environment. Furthermore, the devices of the present invention are preferably configured as disposable devices, however, the devices can also be configured as semi-reusable or reusable without departing from the scope or spirit of the present invention.

System

[00033] Referring to Figure 1, a videoscopic endoscopic vein harvesting system is depicted, generally referred to as reference numeral 600. System 600 includes a retractor generally referred to as reference numeral 50, a multitool device generally referred to as reference numeral 100, and an endoscope 500 slidable within multitool 100. In the perspective view of Figure 1, retractor 50 and multitool 100 are shown in the undocked configuration, and endoscope 500 is shown as detached from multitool device 100.

[00034] Figure 2 depicts retractor 50 and multitool 100 in the docked configuration, and endoscope 500 and camera housing 550 engaged with multitool device 100. A description of the endoscope 500 and camera housing 550 are included in U.S. Patent Application No.

10/259,141, filed on September 27, 2002, and entitled Portable, Reusable Visualization System, the contents of which are hereby incorporated by reference. When endoscope 500 is engaged with a handle 110 of multitool 100, a mating post 501 slides within shield 101. Mating post 501 typically heats up when endoscope 500 is being used and shield 101 serves to protect the user from being burned or distracted by the heat given off by mating post 501. Shield 101 is preferably attached to handle 110 of multitool 100, may be made of a polyurethane, and preferably has a slit 101a to permit mating post 501 to easily slide within sleeve 101.

[00035] Retractor 50 and multitool 100 are described in some detail below as are the details of how and in what manner retractor 50 and multitool 100 are releasably attached or docked to one another.

Retractor

[00036] Referring to Figure 3, a retractor, generally referred to by reference number 50, is depicted. Retractor 50 includes a handle 51, also serving as, and alternatively referred to as a housing, a shaft 52 extending distally from handle 51, and a working head 53 attached to the distal end of shaft 52.

[00037] Retractor 50 is typically used with an endoscope attached to or inserted through handle 51 and beneath shaft 52 so that an operator may view working space created by working head 53. In a preferred embodiment, retractor 50 is used in conjunction with a multitool instrument, more fully described in related U.S. Patent Application Serial No. 10/_____ (Attorney Docket No. ETH-5101), filed on the date of this application, and hereby incorporated by reference. U.S. Patent No. 5,928,138 discloses how devices may be used with other instruments for dissecting and harvesting a vein, the disclosure of which is hereby incorporated by reference.

[00038] Retractor 50 may include a dock port 90 that releasably mates with a dock 140 of a multitool instrument 100 (Figure 1) such that retractor 50 and multitool instrument 100 can be used together. Dock port 90 is preferably formed as part of handle 51. Referring to Figures 3 and 12, handle 51 is generally fabricated from a medical grade plastic and is preferably formed in a "clamshell" design having first and second halves 51a, 51b. The clamshell design allows for easy assembly of the internal components. The halves 51a, 52b are fixed together by any means known in the art, such as by a press fit, or with a medical grade epoxy or

adhesive, or by ultrasonic welding or by mechanical means, such as by screws, or by any combination of the above.

[00039] As best shown in Figures 1 and 1A, dock port 90 is formed in handle 51 of retractor 50. Dock port 90 includes rails 91 and 92 that project inwardly from handle halves 51a and 51b, respectively, and extend longitudinally in a direction substantially parallel to shaft 52 of retractor 50 from a proximal end 51e to a distal end 51f of handle 51. Halves 51a, 51b are attached at a joint that extends generally along a medial plane M. Projections 94 and 95 project upwardly from the surface of rails 91 and 92, respectively, at a position near distal end 51f of handle 51. Slots 96 and 97 are formed in projections 94 and 95, respectively. Dock port 90 can also include a rib 93 that extends inwardly from handle half 51b at a position between proximal end 51e and distal end 51f of handle 51.

[00040] Referring to Figures 3 and 11, shaft 52 is fabricated from a medical grade resilient material, such as stainless steel. A proximal end 52a of shaft 52 is attached to a member 56, which extends upwardly from proximal end 52a. Member 56 may have openings 56a, 56b to facilitate attachment to handle 51 by any means known in the art, such as a press fit or a medical grade epoxy or adhesive or by heat-staking. Preferably, openings 56a and 56b of member 56 are sized to accommodate projections 58a, 58b (Figure 12) that extend from each of halves 51a, 51b of handle 51 such that when halves 51a and 51b are brought together, the pairs of projections 58a and 58b capture member 56 by extending through openings 56a, 56b. A distal end 52b includes an opening 55 that is dimensioned to mate with a portion 53a of working head 53. Opening 55 is preferably formed by removing material from a cross-sectional portion of shaft 52. The removal of material to form opening 55 can be done by conventional machining or punching processes known in the art. Portion 53a of working head 53 is affixed to shaft 52 by any means known in the art, such as by a press fit and/or with a medical grade epoxy or adhesive. Shaft 52 is preferably shaped to form channels 52d and 52e (Figure 5A) along a portion of the longitudinal length of shaft 52.

[00041] Working head 53 is useful for grossly dissecting tissue away from a vessel, such as the saphenous vein, when introduced through an incision in tissue, and creating a working space to permit the separation of the vessel from the surrounding tissue during EVH. Working head 53 is preferably made of a medical grade, injection-moldable plastic, such as polycarbonate, and is optionally clear for endoscopic viewing of tissue both inside and adjacent to working head 53. As is shown in Figure 5A, working head 53 is preferably symmetrically shaped about a medial plane M and is generally concave.

[00042] Referring to Figures 9 and 11, working head 53 tapers to a distal end 54 having a leading edge 54a so that an operator can easily use working head 53 to separate tissue layers and isolate a vessel from surrounding tissues. As is shown in Figure 5A, working head 53 may have a notch 54b in leading edge 54a to provide for better visualization and management of anterior side branches. Working head 53 includes an outer surface 53b that terminates at a peripheral edge 53c. Working space 57 is defined as the area between the tissue overlying the blood vessel and the tissue underlying the blood vessel separated by working head 53. Working head 53 also includes recesses 53d and 53e spaced apart laterally from one another and substantially aligned with channels 52d and 52e, respectively, of shaft 52.

[00043] Working head 53 may have a spoon-shaped configuration, or it may consist of a bridge that extends for a portion or the full length of shaft 52, such as those depicted in U.S. Patent No. 6,080,102, the disclosure of which is incorporate by reference. For example, working head 53 may consist of a tube having a semi-circular or a rhomboidal cross section when viewed axially. Such tubes may be entirely enclosed or have windows created therein. Working head may be slidable or fixed relative to shaft 52. In short, working head 53 can be any shape that defines a working space 57 that facilitates the introduction of instruments into working space 57 in order to perform various steps of a surgical procedure.

[00044] Referring generally to Figure 11, retractor 50 also includes a vessel retractor system for manipulating a vessel proximate working space 57 during EVH by repositioning it within the operating field. In a preferred embodiment, the vessel retracting system includes a first manipulator 60, a first actuation system 68 (Figure 12), a second manipulator 70 and a second actuation system 78. While the preferred system includes a first and second retractor, retractor 50 can include one or more retractors. In a preferred embodiment, retractor 50 includes a first manipulator 60 and a second manipulator 70, each disposed at least partially within working space 57. First manipulator 60 includes a first rod 61 having a proximal end 61a, a distal end 61b and a distal portion 61c, and a first paddle 62 extending from the distal portion 61c. First rod 61 is preferably made from stainless steel wire having a diameter approximately in the range of .025 inch to .075 inches, but most preferably .050 inches. A portion of rod 61 is disposed within channel 52d of shaft 52 with distal portion 61b extending beyond distal end 52b of shaft 52 and within working space 57. Distal end 61b is disposed within recess 53d of working head 53. Channel 52d and recess 53d are configured to retain a portion of rod 61, while permitting rod 61 to rotate freely within channel 52d and recess 53d.

First paddle 62 is preferably attached to first rod 61 by laser welding, but could be attached by any means known to one skilled in the art.

[00045] Similarly, second manipulator 70 includes a second rod 71 having a proximal end 71a, a distal end 71b and a distal portion 71c, each of which are not shown in the figures, but are similar in form and function to the corresponding elements 61a, 61b and 61c of first manipulator 61. Manipulator 70 also includes a second paddle 72 extending from the distal portion 71c. Second rod 71 is preferably made from stainless steel wire having a diameter approximately in the range of .025 inch to .075 inches, but most preferably .050 inches. A portion of second rod 71 is disposed partially within channel 52e of shaft 52 with distal portion 71b extending beyond distal end 52b of shaft 52 and within working space 57. Distal end 71b is disposed within recess 53e of working head 53. Channel 52e and recess 53e are configured to retain a portion of second rod 71, while permitting second rod 71 to rotate freely within channel 52e and recess 53e. Second paddle 72 is attached to second rod 71 by laser welding, but could be attached by any means known to one skilled in the art.

[00046] Referring to Figure 3, first paddle 62 and second paddle 72 are positioned offset distally from one another so as that one paddle does not to interfere with the other paddle's motion. Thus, first paddle 62 extends from first rod 61 at a location distal to the location where second paddle 72 extends from second rod 71. As such, first paddle 62 is retained within working head 53 at a location distal in a longitudinal direction to second paddle 72. Of course, either paddle could be configured in this way. In addition, first rod 61 and second rod 71 are offset from one another relative to the medial plane M of working head 53.

[00047] Referring now to Figures 4, 10 and 12, retractor 50 includes first actuation system 68 for moving paddle 62 between the retracted or stowed position and the extended position. In addition, the retractor 50 includes second actuation system 78 for moving paddle 72 between the retracted position and the extended position. The first actuation system is actuated by moving a first actuator 66 movably disposed in handle 52. First actuator 66 is preferably slidably disposed in handle 52 and operably connected to first paddle 62, such that moving first actuator 66 a predetermined distance rotates first paddle 62 between the retracted and extended positions. Similarly, the second actuation system is actuated by moving a second actuator 76 movably disposed in handle 52. Second actuator 76 is preferably slidably disposed in handle 52 and operably connected to second paddle 72, such that moving second actuator 76 a predetermined distance rotates second paddle 72 between the retracted and extended positions.

[00048] In a preferred embodiment, first actuator 66 of first actuation system 68 is operably attached to first paddle 62 so as to translate a linear motion to a rotational motion. First actuator 66 includes a first button 69 that the user moves to generate rotation of first paddle 62. First actuator 66 preferably also includes a slide 67 either integral with or separably attached to first button 69. First slide 67 is configured to retain one end of a wire 65 and to slidably ride in a slot 82a formed by lip 51c of handle 51 and a spacer 80. First wire 65 is connected at a distal end to first slide 67 and at a proximal end to a first rack 64. First rack 64, in turn is matingly engaged with a first pinion 63, which is preferably attached on one side to proximal end 61a of first rod 61 and rotates in a slot formed by backplate 81 and handle half 51a. Similarly, second actuator 76 of second actuation system 78 is operably attached to second paddle 72 so as to translate a linear motion to a rotational motion. Second actuator 76 includes a second button 79 that the user moves to generate rotation of second paddle 72. Second actuator 76 preferably also includes a slide 77 either integral with or separably attached to second button 79. Second slide 77 is configured to retain one end of a wire 75 and to slidably ride in a slot 82b formed by lip 51c of handle 51 and a spacer 80. Second wire 75 is connected at a distal end to second slide 77 and at a proximal end to a second rack 74. Second rack 74, in turn is matingly engaged with a second pinion 73, which is preferably attached on one side to proximal end 71a of second rod 71 and rotates in a slot formed by backplate 81 and handle half 51b.

[00049] Referring to Figure 12, in a preferred embodiment, first and second racks 64, 74, first and second pinions 63, 73, and backplate 81 are all disposed within handle 51. Actuators 66, 76, racks 64, 74, pinions 63, 73 and spacer 80 are all preferably formed of a medical grade, injection moldable plastic, such as glass-filled nylon. Wires 65 and 75 are formed of a relatively flexible metal, such as stainless steel, and preferably range from .02 to .04 inches in diameter, and most preferably, is approximately .03 inches in diameter. Backplate 81 is preferably formed of stamped stainless steel.

[00050] Referring to Figure 3, first button 69 and second button 79 are shown in their most proximal position, or the position closest to the operator's hand, within slots 82a and 82b. In this position, paddles 62 and 72 are retained within working head 53 in their stowed or retracted position. Referring to Figure 4, displacement of first button 69 distally (or away from the operator's hand), in a direction depicted by arrow A, causes first wire 65 to move upwardly and distally (shown by broken arrow B), which in turn causes the first rack 64 to move upwardly. The motion of first rack 64 in turn causes first pinion 63 to rotate in the

clockwise direction depicted as arrow C. As pinion 63 is attached to rod 61, rotation of first pinion 63 causes first paddle 62 to also rotate in the clockwise direction. Similarly, referring to Figure 5, moving second button 79 distally in a direction depicted by arrow D causes second wire 75 to move upwardly and distally, which in turn causes second rack 74 to move upwardly, causing second pinion 73 and second paddle 72 to rotate in a counter-clockwise direction shown by arrow E.

[00051] First button 69 and second button 79 are positioned side by side such that a user that grasps retractor 50 with one hand, may actuate either or both buttons by using a thumb or finger. Thus, the user can manually retract tissue to form working space 57 and retract the vessel being harvested by using retractor 50, without the need for a separate instrument. Further, because retractor 50 includes first paddle 62 on one side of the medial plane M of retractor 50 and second paddle 72 on the other side of the medial plane of retractor 50, the user may move the vessel to one side away from the medial plane of retractor 50 using first paddle 62 or the other side away from the medial plane of retractor 50 using second paddle 72, without the need to reposition or rotate retractor 50. Thus, in the event the user would like to transect a side branch on the right side of vessel, the user can use first paddle 62 to manipulate the vessel away from the side branch, and, similarly, where the user would like to transect a side branch on the left side of vessel, the user can use second paddle 72 to manipulate the vessel away from the side branch.

[00052] While the preferred embodiment depicts a first and second actuation system 68, 78, it is contemplated that first retractor and second retractor could be actuated using one actuation system. For example, rather than having buttons that go up and down, a single button can be toggled left or right to engage slide 67 or slide 77 depending upon which manipulator the user wanted to actuate. As a result, other than the toggle motion, the remainder of the actuation mechanism would work similarly to the described device; i.e., slides 67, 77 could move wires 65, 75 and racks 64, 74 to act upon pinions 63, 73 and manipulators 60, 70.

[00053] Referring to Figures 6-9, the details of the distal end of retractor 50 are shown. Referring to Figure 6, first paddle 62 and second paddle 72 are shown in their stowed or retracted position. First paddle 62 and second paddle 72 are positioned to nest longitudinally in a side-by-side configuration close to a portion of the interior surface 53f of working head 53. In the stowed position, first paddle 62 and second paddle 72 are preferably shaped to substantially minimize the amount of working space obstructed by the paddles themselves.

Preferably, as is shown in Figure 7, first paddle 62 may rotate about the pivot point defined in recess 53d through an arc F of approximately 100 to 140 degrees, but most preferably 120 degrees. Similarly, as is shown in Figure 8, second paddle 72 may rotate about the pivot point defined in recess 53e through an arc G of approximately 100 to 140 degrees, but most preferably 120 degrees. In each case, however, it is contemplated that the angle of rotation could be greater or smaller depending upon the location of recesses 53d, 53e and the curvature of working head 53.

[00054] As is shown in Figures 7 and 9, first paddle 62 extends below peripheral edge 53c defined by working head 53 when first paddle 62 is in the extended position. Preferably, first paddle 62 has a curved portion that forms a concave surface that faces away from working head 53 when in the extended position. In a preferred embodiment, when in the fully extended position, paddles 62 and 72 extend a distance X of approximately .10 inches to .25 inches medially outwardly (Figure 6) from working head 53, but most preferably approximately .15 inches, and downwardly (Figure 9) from working head 53 a distance Y of approximately .15 inches to .35 inches, but most preferably approximately .20 inches. When paddle 62 or 72 is extended below peripheral edge 53c normal to pivot point 53d, 53e, the tip of paddle 62, 72 (Figure 8) preferably extends a distance Z of approximately .15 inches to .35 inches below edge 52c, but most preferably approximately .25 inches. The length of the paddles is preferably configured to be long enough to manipulate a vessel to a position that does not interfere with the working space, but short enough so as not to be prevented from rotating by the layer of tissue at the bottom of the working space when the paddles are actuated.

Multitool device

[00055] Referring now to Figures 1 and 13, multitool device 100 is depicted. Multitool 100 is described in detail in related U.S. Patent Application Serial No. 10/_____ (Attorney Docket No. ETH-5101), filed on the date of this application and assigned to Ethicon, Inc, and hereby incorporated by reference. Multitool 100 includes a surgical device 300 that is slidable within tube 124, and includes a shaft 304 having an opening 306 at a distal end configured to capture tissue. Surgical device 300 includes an anvil assembly 302 slidable within shaft 304 for clamping tissue captured within opening 306 and a cutting blade 314 slidable within shaft 304 for cutting the captured tissue. Surgical device 300 also includes at least one electrode for providing RF energy to desiccate the captured tissue.

[00056] Multitool device 100 preferably includes a handle 110, also serving as, and alternatively referred to as a housing. Handle 110 has a button 115 slidably disposed therein, and a cannula 120 that projects from handle 110. Handle 110, as with handle 51 of retractor 50, is fabricated from a medical grade thermoplastic and is preferably formed in a "clamshell" design having first and second halves 110a, 110b. The clamshell design allows for easy assembly of the internal components. The halves 110a, 110b are fixed together by any means known in the art, such as by a press fit, or with a medical grade epoxy or adhesive, or by ultrasonic welding or by mechanical means, such as by screws, or by any combination of the above. Handle 110 has a proximal end 110c and a distal end 110d. Proximal end 110c is configured to mate with a camera portion (not shown), which is described in detail in U.S. Patent Application No. 10/259,141, filed on September 27, 2002, and entitled Portable, Reusable Visualization System, the contents of which are hereby incorporated by reference.

[00057] Handle halve 110a has a slot 116 formed therein. Slot 116 has a first track 117a, a second track 117b that communicates with first track 117a, and a third track 117c that communicates with second track 117b. First track 117a is preferably located on one side of a medial plane M and extends longitudinally toward the distal end of shaft 304. The medial plane M is centered along the longitudinal axis of tubes 123, 124. Second track 117b also extends longitudinally, is preferably located on the other side of medial axis M and is connected to first track 117a by a fourth track 117d that extends substantially normal to first track 117a and second track 117b. Third track 117c begins at the distal end of second track 117b and extends longitudinally along a line substantially along medial axis M.

[00058] Cannula 120 of multitool device 100 preferably has two lumens, but may have additional lumens. In the preferred embodiment, a first lumen 121 is sized to accommodate an endoscope, and a second lumen 122 is sized to accommodate a tool such as a surgical device 300. Cannula 120 may be formed of a metal, or of a hard plastic or of a combination of metal and plastic. In a preferred embodiment, first and second lumens 121, 122 of cannula 120 are formed by separate tubes 123, 124 that are spaced with respect to one another by a spacer 102 that extends for a desired length between tubes 123, 124. Tubes 123, 124 are alternatively referred to as shafts. Tubes 123, 124 provide rigidity as they are preferably formed of a metal, however, tubes 123, 124 are not essential to the invention as long as the endoscope and surgical device 300 are fixed with respect to each other and multitool device 100 is of sufficient rigidity.

[00059] First tube 123 is dimensioned to house an endoscope (not shown) that is passed through handle 110 from a proximal end to the distal end and through tube 123 such that it extends distally from the distal end of tube 123. Tubes 123, 124 have a length of length of approximately 10.5 inches, and a diameter of about .25 inches. First and second tubes 123, 124 are preferably fixed with respect to one another by an outer sheath 125 that extends longitudinally along a substantial portion of tubes 123, 124. Sheath 125 is preferably heat shrunk around tubes 123, 124.

[00060] As discussed above, retractor 50 may include a dock port 90 to mate with a dock 140 of a multitool instrument 100 so retractor 50 and multitool instrument 100 can be used together. Dock 140 and dock port 90 include at least one docking feature that secures dock 140 and dock port 90. One skilled in the art can devise numerous docking features, among which would be a latch, a rail and slot configuration, a luer lock. It should be understood that multitool instrument 100 may include one or more different surgical devices and does not necessarily need to include an endoscope. For example, an endoscope can be supplied with retractor 50.

[00061] Returning to the description of multitool device 100 and referring to Figures 13 and 14, device 100 also includes a dock 140 preferably located between the proximal end of tubes 123, 124, and handle 110. Dock 140 is preferably formed of a hard plastic that is injection molded to form features that mate and interact with dock port 90. Dock 140 preferably includes a passageway 141 that accommodates lumens 121, 122, a proximal end 142 having a projection 142a that is captured within joined handle halves 110a and 110b of multitool handle 110, and a distal end 143 that is configured to be disposed within dock port 90 of retractor 50 when retractor 50 and multitool device 100 are in the docked configuration.

[00062] Dock 140 preferably includes projections 147 on either side (only one of which is depicted in Figure 14). Projections 147 each have a slot 148 formed therein at a location preferably substantially aligned with the upper edge of second lumen 122 or second tube 124 when dock 140 and dock port 90 are in the docked configuration. Projections 147 and slots 148 are preferably formed in dock 140 by injection molding and are configured to slidably accept rails 91 and 92, respectively, of retractor 50. Slots 148 each have at a distal end thereof a mouth 148a that is slightly larger than the remainder of slot 148 to permit rails 91 and 92 to be more easily slid into slots 148. Preferably slots 148 are wider than the width of rails 91, 92 such that there is some play between slots 148 and rails 91, 92. Mouths 148a and the play between slots 148 and rails 91, 92 permit multitool device 100 to be pivoted downwardly

with respect to retractor 50. To further secure multitool device 100 to retractor 50, dock 140 may include ridges 147a (one on either side of dock 140) that are configured to be accepted in slots 96 and 97 of dock port 90.

[00063] Referring to Figure 14, dock 140 also includes a latch 145, and a leaf spring 146 positioned distally to latch 145. Latch 145 projects upwardly from an upper surface 140a to form a leg 145a, and extends substantially longitudinally at a location spaced apart from upper surface 140a to form an arm 145b having a distal free end 145c. Arm 145b includes a distal projection 145d at a distal end that has a face 145e, that extends substantially parallel to leg 145a, and a ramp 145f that angles downwardly toward upper surface 140a. Leaf spring 146 projects upwardly from upper surface 140a distal a window 140b in upper surface 140a, and includes a first leg 146a, a beam 146b that extends proximally from first leg 146a, and a second leg 146d that extends from the proximal end of beam 146b. Second leg 146d preferably includes a seat 146c that is formed as an arc that is configured to ride on the outer surface of tube 123 when beam 146b is deflected.

[00064] Figure 15 depicts a plan view of retractor 50 and multitool 100 in the docked configuration. Dock 140 and port 90 are configured such that the end effector of surgical device 300 of multitool 100 is positioned within working space 57 when dock 140 and port 90 are in the docked configuration.

[00065] In the docked configuration, the distal end of multitool 100 is disposed within working space 57 of retractor 50 and advantageously minimizes the stack-up height of the docked instruments. Referring to Figure 1, the height x_1 of multitool 100 is approximately .53 inches. Referring to Figure 10, the height x_2 of shaft 52 of retractor 50 is approximately .28 inches and the height x_3 measured from the top of working head to the lower edge of peripheral edge 53c is approximately .53 inches. Referring to Figure 15, the height x_4 of retractor 50 and multitool 100 at a location where the docked devices enters an incision is approximately .66 inches, and the height x_5 measured from the top of working head 53 to the underside of distal end 304c of shaft 304 of multitool 100 is approximately .57 inches. Thus, in the docked configuration shaft 304 of multitool 100 is slightly biased toward the underside of working head 53 as the stack-up height decreases from .66 inches at the typical point of insertion to .57 inches at the most distal location of the docked devices. As a result, retractor 50 when docked with multitool 100 only creates an additional stack up height of approximately .04 inches at the distal-most point. This arrangement provides the user with sufficient operative space, while minimizing the amount of tissue trauma (as the , and permits

easy movement of the multitool 100 through the operative space, whether in a docked or undocked configuration.

[00066] Referring to Figures 1 and 14, when a user wishes to place multitool device 100 in the docked configuration with retractor 50, the user positions retractor 50 over the upper surface of tube 123 (or sheath 125 that covers tube 123), and aligns port 90 with dock 140. The user slides retractor shaft 52 over tube 123 such that rails 91, 92 enter mouths 148a of slots 148 until proximal end 51e of handle 51 contacts ramp 145f. As the proximal end 51e rides up ramp 145f, latch 145 deflects toward upper surface 140a. When proximal end 51e clears ramp 145f, face 145e resides within handle 51 and abuts an inner surface 51g (Figure 10) of handle 51, and projections 147 of dock 140 reside within slots 96 and 97 of port 90. In this manner, longitudinal or axial movement of multitool 100 with respect to retractor 50 is prevented.

[00067] In addition, at this position, beam 146b pushes against rib 93 of retractor 50 thereby biasing the end effector or distal end of multitool 100 toward working head 53 of retractor 50. The user may, however, exert a spreading force on the handle 51 of retractor 50 and/or handle 110 of multitool 100 that can deform beam 146b such that seat 146c slides proximally on upper surface of tube 123 thereby temporarily overcoming the spring force of leaf spring 146 and permitting the distal end of multitool 100 to be deflected downwardly with respect to working head 53. In this manner, the user is provided a degree of freedom (DOF) for extra manipulation to, for example, to stow manipulators 62, 72 without having to undock retractor 50 from multitool 100. When hand pressure is removed by the user, the distal end of the multitool 100 is automatically biased upwards due to leaf spring 146.

[00068] To undock the multitool from retractor, the user presses downwardly on a concave surface 145g of latch 145 such that distal end 145c of latch 145 moves downwardly out of engagement with proximal end 51d of housing 51 thereby permitting the user to move retractor 50 distally with respect to multitool 100 to separate one from the other.

[00069] Figures 13 and 14 depict one embodiment of a docking arrangement. While dock 140 is shown with two slots 148, dock 140 does not necessarily require any slots or could use just one slot formed, for example, at the lower edge of dock 140, or more than two slots. Other arrangements can clearly be envisioned by those skilled in the art. For example, a fully rigid dock that eliminates all degrees of freedom; a dock that permits axial or longitudinal movement; a dock that permits axial rotation or radial movement of multitool 100; a detent dock, or any combination of the above. In addition, while port 90 is described as an element

of retractor 50 and dock 140 is described as an element of multitool 100, those skilled in the art will understand that the reverse design will work just as well. That is, multitool 100 can include a port 90 and retractor 50 can include a dock 140.

[00070] Referring to Figures 1 and 13, surgical device 300 is depicted. Surgical device 300 includes a shaft 304, a tip 313 disposed at a distal end of shaft 304, an anvil 308 disposed at least partially within shaft 304, at least one electrode for cauterizing tissue, and a cutting blade 314 also disposed at least partially within shaft 304. Shaft 304 is preferably at least partially slidably disposed within tube 124. Shaft 304 has a first internal lumen 304a, a proximal end 304b and a distal end 304c. Shaft 304 is fabricated from a medical grade resilient material, such as stainless steel, and preferably is affixed at proximal end 304b to a sled 350 by any means known in the art such as by press fit or with an adhesive. Preferably, proximal end 304b is attached to distal end 350a of sled 350 within an opening 351 in distal end 350a.

[00071] Shaft 304 has an opening 306 at a distal end 304c. Opening 306 is preferably formed by removing material from a cross-sectional portion of the shaft 304 such that opening 306 has a peripheral edge 306a defining the boundaries of opening 306. The removal of material to form opening 306 can be performed by conventional machining or punching processes known in the art. Opening 306 may be configured to accommodate the largest size blood vessel possible for a given diameter of shaft 306. In a preferred embodiment, shaft 304 diameter is approximately 2 mm, and opening 306 has a mouth length x_1 (Figure 30C) of approximately 5 mm and an overall length x_2 (Figure 30C) of approximately 7 mm. This configuration permits blood vessels as great as 6 or 7 mm to be accepted within opening 306 due to the flexibility of blood vessels.

[00072] Figures 16A and 16B are side and end sectional views of a first alternative docking arrangement that includes dock 140′. In this embodiment, which is not drawn to scale, dock 140′ has an opening 141′ and includes latch 145′. Latch 145′ is configured to permit radial movement of the multitool with respect to the retractor. Multitool 100 is omitted from the drawing for clarification purposes. As with the embodiment described above, multitool device 100 is passed through opening 141′ and at least partially disposed within dock 140′. Latch 145′ includes a distal end 145d′ that has a convex surface. Housing wall 51e has a lower surface 51e′ that is shaped to mate with convex surface 145d′. Thus, when distal end 145d′ is captured within housing wall 51e, dock 140′ is permitted to rotate in the directions shown as arrows A and A′ causing multitool 100 to be rotated as well. This

arrangement permits the distal end of multitool 100 to be rotated to capture a vessel more readily. Housing 51 can be supplied with stops 51h that interact with projections 145h of dock 140′ to limit the amount of rotation.

[00073] Figures 17A and 17B are side and end sectional views of a second alternative docking arrangement that includes dock 140″. In this embodiment, which is not drawn to scale, dock 140″ has an opening 141″ and a slot 140i, and includes a latch, which is not shown for clarity. This embodiment also includes a sled 149 that is attached to multitool 100. Sled 149 has an opening 149a, within which multitool 100 is at least partially disposed, and includes a lever 149b that extends from a surface of sled 149 through slot 140i. In this manner, when dock 140″ is attached to port 90, multitool 100 may be moved axially by moving lever 149b within slot 140i. Those skilled in the art can design different means of locking lever 149b in place within slot 140i.

[00074] While port 90 is described as an element of retractor 50 and dock 140 is described as an element of multitool 100, those skilled in the art will understand that the reverse design will work just as well. That is, multitool 100 can include a port 90 and retractor 50 can include a dock 140. Each of the above-described configurations can be modified to have retractor 50 include the male mating component and multitool 100 include the female mating component.

[00075] For example, Figures 18A and 18B depict perspective views of a third alternative embodiment of a dock and a dock port in an undocked configuration and a docked configuration. Figure 18A depicts a retractor 250 and a multitool 300, respectively configured similarly to retractor 250 and multitool 300 described above. Retractor 250 includes a handle 251, preferably formed of handle halves 251a and 251b, and a shaft 252 extending from handle 251. Handle 251 includes an opening 290 in a proximal end 251e of handle 251, and rails 291 and 292 that project inwardly toward opening 290 from handle halves 251a and 251b, respectively. Retractor 250 also includes a latch 345 that extends proximally from proximal end 251e of handle 251 and includes a distal end 345e.

[00076] Multitool 300 comprises a housing 310 and a cannula 320 extending distally from housing 310. At least a portion of cannula 320 is configured to pass through opening 290 of retractor handle 251. Cannula 320 has grooves 348 on either side of cannula 320 that are configured to accept rails 291 and 292 of handle 251 when cannula 320 is disposed within opening 290. Housing 310 has an opening 301 that is configured to accept distal end 345e of latch 345 when cannula 320 is disposed within opening 290 of handle 251.

[00077] As is shown in Figure 18A, to releasably attach retractor 250 and multitool 300, handle 251 is aligned over cannula 320 of multitool 300 and rails 291 and 292 are slid into grooves 348 until distal end 345e of latch 345 is disposed within opening 290 of handle 251. Preferably, distal end 345e interacts with an element within housing 310 to affirmatively latch retractor 250 to multitool 300.

[00078] Like the preferred embodiment described above, the user has the ability to work with retractor 250 and multitool 300 in a docked or undocked configuration. To undock the multitool from retractor, the user presses downwardly on latch 345 such that distal end 345e of latch 345 moves downwardly out of engagement with housing 210 thereby permitting the user to move retractor 250 distally with respect to multitool 300 to separate one from the other.

Method of Use

[00079] To utilize the system 600, a physician or physician's assistant determines the location of a vessel to be dissected, and makes an incision in the patient. The user then inserts retractor 50 into the incision and bluntly dissects the tissue surrounding vessel using working head 53. If the intention is to extract vessel 5 (Figure 9), it is preferable to dissect as much tissue from around the vessel as possible. The user manipulates retractor 50 to advance working head 53 along vessel 5, separating tissue from vessel 5 and providing a working space for accessing and visualizing vessel 5 and a plurality of side branches, one of which is shown as reference numeral 6.

[00080] The user then uses multitool instrument 100 to free vessel 5 from the surrounding tissue and isolate side branches of the vein that must be ligated prior to removal of vessel 5 from the patient's leg. As noted above, multitool instrument may be located above vessel 5, when docked with retractor 50, or may be positioned below shaft 52 of retractor 50 in an undocked configuration.

[00081] Referring to Figure 9, the user manipulates either paddle 62 and/or 72 of retractor 50 to position vessel 5 away from multitool 100 permitting the user to dissect, clamp, coagulate, and cut tissue within working space 57. In particular, when side branches 6 are encountered, the user can manipulate vessel 5 using, for example paddle 62 of retractor 50 such that vessel 5 is protected. In this manner, side branches 6 are isolated and exposed and surgical device 130 introduced via multitool 100 (or through cannula 252) can cauterize and cut side branch 6 without damaging vessel 5.

[00082] The harvesting procedure continues in this manner until the vessel is hemostatically isolated from the surrounding tissues and blood supply along the portion to be harvested. Once the user completes the dissection and vessel 5 is freed of its surrounding tissue, retractor 50 can be withdrawn through the incision. Vessel 5 can then be removed from its native location and prepared for use in a coronary bypass procedure, for example.

[00083] It should be understood that paddles 62, 72 can operate in tandem or can be manipulated such that they work independently of one another. For example, paddle 62 can be extended independently of paddle 72 as it is positioned distally to paddle 72. Paddle 72 may also bypass paddle 62 by first extending each paddle to a position forward of the distal end of cannula 52, rotating paddle 72 such that it does not interfere with paddle 62, and then retracting paddle 62 into the stowed position within cannula 52.

[00084] Retractor 50 is especially suited for vessel harvesting, but are not limited to this surgical procedure. Retractor 50 may be used to retract many different types of tissue, and, similarly, multitool instrument 100 may be used to dissect, clamp, coagulate, and cut tissues during other types of endoscopic and open surgical procedures. For example, the instruments can also be used to remove other discrete tissues, such as tumors, to ligate fallopian tubes for fertility control, to ligate and transect bile ducts for nephrectomy, or to transect ligaments or other tissue structures.

[00085] While there has been shown and described what is considered to be preferred embodiments of the invention, it will, of course, be understood that various modifications and changes in form or detail could readily be made without departing from the spirit of the invention. For example, while handle 51 is depicted as an L-shaped handle, the handle could be an in-line handle, which is well-known in the art. It is therefore intended that the invention be not limited to the exact forms described and illustrated, but should be constructed to cover all modifications that may fall within the scope of the appended claims.